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Design and Implementation of City Fire Rescue Decision Support System

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Abstract

The authors introduced major geographic data management platform ARCGIS, and developed city major fire extinguishing rescue decision support system based on GIS, by using ArcGIS Engine and VB, according to a large number of decision support system and fire fighting rescue strength model advanced. City major fire extinguishing rescue decision support system based on GIS is integrated with several functions, including layer management, query, fire analysis, fire force calculation, and dynamic visualization plan of fire fighting and rescue. This paper mainly introduced the system function, system design and system implementation.

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1. Introduction

With the fast development of city construction, fire protection work occupies a more and more important part in the city disaster of prevention and reduction [1], City fire decision requires large amounts of comprehensive and accurate information, and requires fast and accurate decision-making and avoiding delaying to extinguish fire [2, 3]. The improper command is one of the reasons of Xi'an liquefied gas explosion. There was a lack of scientific rescue force model which failed to quickly dispatch the rescue force, delaying the rescue time, resulting in a large number of casualties and property losses. Therefore, the development of city major fire extinguishing rescue decision support system based on GIS is imperative, so that the fire department quickly generate the rescue plan and effectively dispatch force and scientifically use fire resources, in order to minimize the loss of life and property with minimal cost.

2. System functions and design process

2.1 System functions

The system is capable of managing and operating effectively all kinds of spatial and non spatial attribute data, in which, all kinds of key unit with fire and explosion risk and the city fire brigades are managed graphically, which greatly improves the work efficiency of the fire department, at the same time, the system realizes the functions of fire locating, fire fighting force calculation and so on based on effective management of large spatial database for all kinds of data, by application of geographic information system spatial analysis model and fire related calculation model, which improve the fire rescue team

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overall emergency response and joint combat capability. Its functions is shown in figure 1

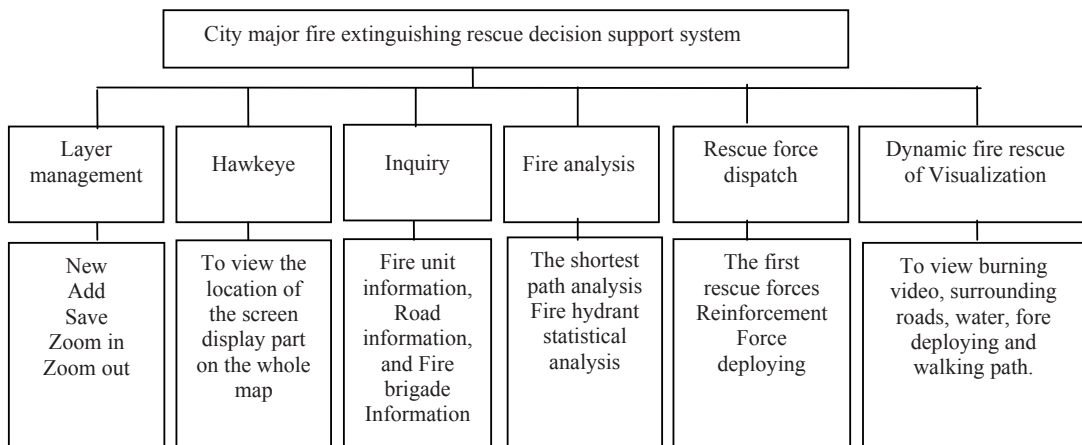


Fig 1 systems function diagram

2.2 System design process

Basic design idea of the system is to use the functions that ArcGIS manage effectively map data and flexibly display data, then, to use VasiualBasic6.0 to realize that fire spatial data and attribute data support the functions of fire command and decision. System design process is in figure 2.

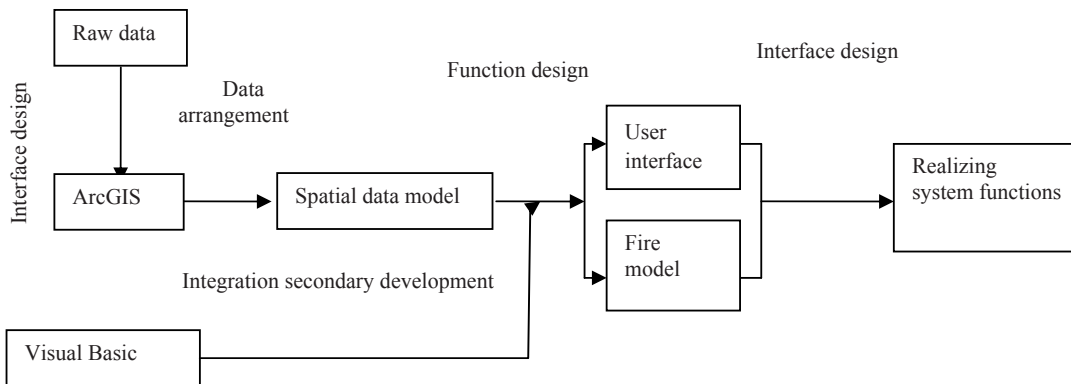


Fig 2 system design flowchart

3. The design of fire extinguishing rescue decision support system

3.1 The principle of system design

Application of GIS system function design should abide by the following principle ^[4]:

Firstly, System function structure rationality: It refers to the system function was divided and integrated reasonably according to design ideas of system theory.

Secondly, System function structure Completeness: The system is fully functional; meet the application requirements, according to the system application requirements.

Thirdly, independence characteristic among system function modules: all kinds of modules should be independent on each other, each function has a set of completed processing functions.

Fourthly, the system reliability of function modules: System operation should be reliable.

Fifthly, easy operation characteristic of Function module: The child modules should be operated conveniently, which is simple and clear, and easily operated by fire personnel who are not majored in GIS.

3.2 The system running environment

1) Hardware Environment

- (1) CPU: \geq Pentium4 2.4GHz
- (2) computer internal memory: \geq 256MB
- (3) computer hard disk: \geq 80G
- (4) internal memory of the graphics processor: \geq 64M

2) Software environment

- (1) Operating System: Microsoft Windows XP Professional
- (2) Development Environment: ArcGIS Desktop 9.3; ArcGIS Engine Developer Kit 9.3.1; Visual Basic 6.0
- (3) Database: Microsoft office Access 2003

3.3 System database design

Database is the core of the system components, and directly determines the system successfully achieves or not. The establishment of the system database by two ways, a kind of data is related to map, which is created database through the file Geodatabase of ARCGIS and the other is not associated with map, which is created by the Microsoft Office Access database.

The first class, the data related to map, The database contains spatial data and corresponding attribute data. They are joined together through a field OBJ which is the interface of spatial data and attribute data^[5,6]. According to fire GIS's actual situation, and the system database's contents, the system establish the following layers:

- ① Buildings layer: fw.map, including Residents, industrial and mining enterprise institutions
- ② Road boundary layer: road.map, including various levels of sideline for roads and bridges;
- ③ Road center line layer: roadc.map, including the main road, secondary road, branch;
- ④ water layer Sxa.map, Including rivers, lakes, ponds, ditches
- ⑤ Fire hydrant layer: xfs.map;
- ⑥ House number layer: mph.map;
- ⑦ Key unit layer: zhongdian;
- ⑧ Fire brigade: xiaofangdui.

The second category refers to the database mainly including the fire-fighting and rescue plans, the first rescue forces deployed solution etc, which does not contain map object. This type of database is mainly used to store relevant knowledge and information, which is convenient for firefighting and rescue command staff to find relevant information, realization of assistant decision function.

3.4 The realization of system functions

1) Layer management implementation

Firstly, the map was added through the mapcontrol control, and then the layer management was achieved by the Visualbasic6.0.the function includes sub functions, such as New, Open Work Area, Add Layer, Save Workspace, Exit .they are able to achieve to open ,close, zoom out,zoom in and so on.

2) Eagle eye view function realization

Hawkeye map in GIS is a basic function, Hawkeye map is also called the thumbnail, which is able to view the map location shown in the frame in the whole map like looking down from the air^[7]. The interface is shown in figure 3

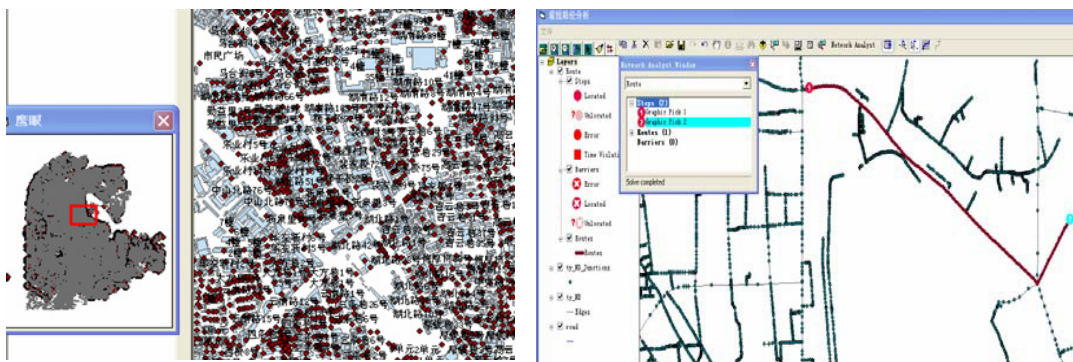


Fig 3 hawkeye interface

Fig 4 the shortest path analysis diagram

3) Fire analysis

(1) The shortest path analysis:

Fire loss has very big fluctuation, which related with fire duration, combustion material category, the fire area and so on. But in the practical work, it is mainly because of all kinds of retardation factors ,for example ,fire resource scheduling is not reasonable, which often make firefighters cannot rapidly arrive to the fire site ,and lead to loss the best time of extinguishing. Therefore, it is necessary for the walking path study of the fire fighting and rescue. The network analysis in geographic information system and the shortest path algorithm can solve this problem well. the author used the method of combining Visual Basic6.0 with ArcGIS to achieve the calculation of the shortest path of the fire, the interface is shown in figure 4

(2) Fire hydrant statistical analysis

Fire departments master the situation of fire units and the number and distribution of the surrounding fire hydrant, which is one of the important factors of successful extinguishing. This paper achieved the fire hydrant quantitative statistics within a certain circle domain which mainly based on the ArcGIS buffer analysis and spatial query function, using the VB program language, the interface is shown in figure 5

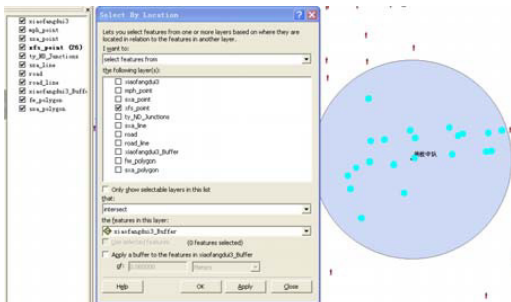


Fig 5 statistical analysis diagram of fire hydrant



Fig 6 the first dispatch power interface diagram

4) Rescue force calculation

The researchers combined with geographic information system and spatial database technology, using the programming language Visual Basic 6.0, and ultimately realized that fire rescue strength is fast, accurate action, based on the model of fire rescue forces, which makes the fire dispatch be more rational, and ultimately makes the fire rescue brigades occupy in initiative position in fire rescue. Fire rescue forces includes the first response force and reinforcements

(1) The first response force

Fire fighters apply the function of the system by selecting fire type, grade, corresponding fire vehicle type and the number will be displayed, which assists fire command department quickly dispatch first rescue force. the interface is shown in figure 6

(2) Fire reinforcement

Due to the complexity and diversity of city fire, a variety of fire places ,difference of fire types as well as the diversity of burning material, it is crucial that fire fighting force be calculated from any angle ,which can determined the result of calculation applies or not in actual fire^[8]. Therefore, researchers calculate fire rescue force by the following fire classification which is from the angle of the different spatial object, that is fire place. The interface of fire fighting force calculation is shown in Figure 7.

Building fire extinguishing force calculation, including general building fire, high-rise building fire , underground building fire, personnel crowded place fire.

Chemical fire extinguishing force calculation, including liquid storage tank fires to type A,B and C , gas storage tank fires to type A and B , Chemical plant fire.

Warehouse fire extinguishing force calculation^[9, 10].

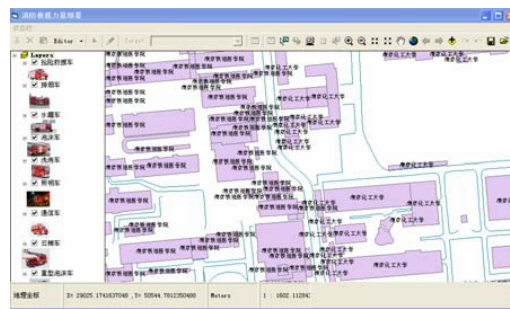


Fig 7 fire fighting force calculation interface

Fig 8 rescue force deployment interface

5) Rescue force deployment

Proper deployment of fire fighting force is the important guarantee for the successful extinguishing. This system has realized the rescue force deployment drills on the map, in order to provide security for carrying out rescue force deployment well. Its function is through the ArcCatalog to build the fire engine feature classes, and then to use ArcMap adding the established feature classes, generating the .mxd file, at last, it is to develop edition function of map by VB and the ArcGIS Engine Developer Kit 9.3.1. the interface is shown in figure 8

6) Visualization plan of key units for fire fighting and rescue

The function was achieved via VB program language, based on established databases, and fire simulation which is built by fire simulation software FDS (Fire Dynamic Simulation), visual presentation software Smoke-View and visual simulation software PyroSim. It is easy to find roads, water, fire force deployment, fire simulation and the shortest rescue path, providing the great help for rapid fire rescue

4. Conclusions

The researchers developed city fire rescue decision support system combining geographic information system with fire related theory, based on the ARCGIS software, the conclusions can be drawn as the following:

- The paper researched extinguishing rescue first response force, reinforcements and realized the purpose that fire brigades rapidly dispatch rescue force.
- Decision support system realized the view of surrounding roads, water, fire power deployment and fire simulation video of dynamic visualization of fire fighting and rescue, which made up for the loss, and enhanced the decision-making role.
- On the whole, from meeting the fire command department needs point of view, city major fire extinguishing rescue decision support system is a strong application system, it covers the fire command responsibility, especially, general functions of fire fighting command system, such as map browsing, path analysis, statistical analysis of fire hydrant. The researchers, combining with the actual needs of firefighting rescue work, focused on the design of fire forces dispatch, rescue force deployment, dynamic visualization of fire fighting and rescue.
- In the Windows XP operating system, using ArcGIS software and related components and visual development tool Microsoft Visual Basic6.0 and Microsoft Office Access database carried out secondary development, realizes the city major fire extinguishing rescue decision support system development. The application of this system will eventually improve the fire fight brigades fighting ability in modern city complex fire.

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